



Barrel EMCal simulations in DD4hep and Fun4All

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BECAL Digitization algorithm in Fun4All

- » Uses “kSiPM_photon_digitization”

https://github.com/ECCE-EIC/macros/blob/a92f9085537508a259e48038fc2199c60223e6fa/common/G4_BECAL.C#L57.

- » ECCE BECAL assumes 5000 photoelectrons/GeV

https://github.com/ECCE-EIC/macros/blob/a92f9085537508a259e48038fc2199c60223e6fa/common/G4_BECAL.C#L118.

- » ... and a default value of 160k pixels – corresponding to 4x Hamamatsu PMTs

<https://github.com/sPHENIX-Collaboration/coresoftware/blob/f5299566b17abcd3ef97389f21672e010847f51a/simulation/g4simulation/g4calo/RawTowerDigitizer.h#L245-L247>.

- » The “kSiPM_photon_digitization” algorithm is implemented in

<https://github.com/sPHENIX-Collaboration/coresoftware/blob/f5299566b17abcd3ef97389f21672e010847f51a/simulation/g4simulation/g4calo/RawTowerDigitizer.cc#L358-L425>.

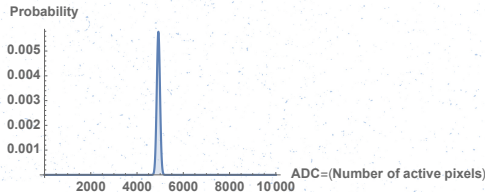
"kSiPM_photon_digitization" in Fun4All

- » Defines a probability for a single pixel to fire:

$$P_{\text{pixel}} = 1 - \exp\left(-\frac{E_{\text{tower}} \times N_{\text{photoelectrons/GeV}}}{N_{\text{pixels}}}\right)$$

$$N_{\text{photons}} \sim \text{Binomial}(N_{\text{pixels}}, P_{\text{pixel}})$$

- » Produces a following distribution of N_{photons} for a 1 GeV tower:



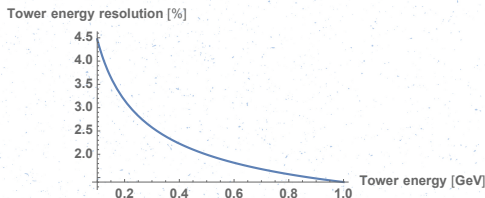
- » And is converted back to energy using a "gain" of $\frac{1}{N_{\text{photoelectrons/GeV}}}$.

"kSiPM_photon_digitization" in Fun4All: resolution

- » The resolution can be calculated as:

$$\frac{\delta E_{\text{tower}}}{E_{\text{tower}}} = \frac{N_{\text{pixels}} \sqrt{P_{\text{pixel}} (1 - P_{\text{pixel}})}}{N_{\text{pixels}} P_{\text{pixel}}}$$

- » Which results in a following dependency:



- » Note that this is for singular towers. For clusters or for full events, the observed resolution will degrade as the energy is split among several towers.

Simulation setups

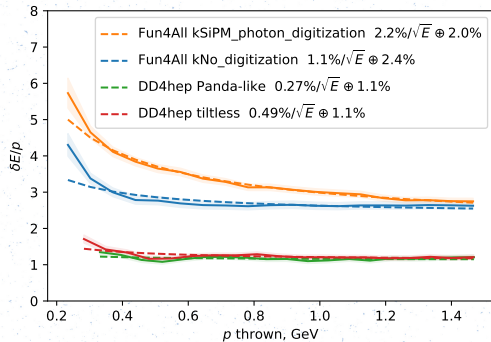
DD4hep

- » `--enableGun --gun.momentumMin '0.15*GeV' --gun.momentumMax '1.5*GeV' --gun.particle e-`
- » No digitization – Only sum all deposited energies
- » Analyzing EDM4hep record from ddsim.

Fun4All

- » `INPUTGENERATOR::SimpleEventGenerator[0]: add_particles("e-", 1), set_theta_range(0, M_PI), set_phi_range(-M_PI, M_PI), set_p_range(0.15, 1.5).`
- » “kSiPM_photon_digitization” or “kNo_digitization”.
- » Analyzing files from the EIC Event Evaluator afterburner.

Resolution from the simulations



Conclusions

- » A single source of discrepancy between Fun4All and DD4hep is found in digitization
- » There seemingly remains another source of discrepancy